INTERNAL WAVES OVER THE CONTINENTAL SLOPE OFF NORTHERNCALIFORNIA

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LONG-TERM GOALS

The long-term goals and scientific objectives of this project are essentially unchanged from last year. This project is in its final year, and some of the results from field experiments have been reported. The primary long-term goal has been to determine the intensity and temporal history of internal waves and tides on the upper continental slope off northern California. A related and ancillary goal is to obtain long-term measurements (~ two years) of the thermal fluctuations in the internal wave band in the study area.

SCIENTIFIC OBJECTIVES

+ Obtain long-term temperature measurements at about 10levels on the STRATAFORM mooring in about 450 m depth to document the temporal variability in the internal wave motion.

+ Using data from the temperature sensors deployed under support from this project, and from the moored current meters supported by STRATAFORM, test the hypothesis that sub critical to critical internal wave motions are intensified over the slope.

+ Evaluate the implications of internal-wave shoaling on sediment transport in this region.

APPROACH

STRATAFORM is a a major program supported largely by ONR - Marine Geology and Geophysics Programs and includes an ambitious field program to obtain detailed bathymetric, geological and oceanographic data aimed at enhancing our understanding of how sedimentary deposits accumulate, change and develop on shelves and slopes. The principal field area is located off the northern California coast seaward of Humboldt Bay and the Eel River mouth. This project was designed to take advantage of the continuing operation of a long-term mooring that is part of the STRATAFORM field work. This project augments the STRATAFORM field efforts by obtaining time-series temperature measurements at several vertical positions on the primary STRATAFORM mooring. Using these data we examine the nature of the internal wavefield, including its seasonal variability, and the relationships between internal waves and bottom slope.

The slope mooring is located in about 450 m depth at41^{o}-03.21' N; 124^{o}-25.90' W. It was initially deployed on September 25, 1995, and is replaced on a schedule of every four months for at least 3 years by the principal investigators from the University of Washington (Dr. Richard Sternberg). The mooring

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contains 3instruments to record horizontal currents, temperature, conductivity and light transmission at water depths of about 60, 180 and 435 m. Sediment traps are also attached near the currentmeters. Based on support from this project, we have attached up to10 recording temperature sensors along the mooring. Temperature at each level is recorded at five minute intervals. The mooring data will comprise an unique, long time series of the various parameters, from which low frequency, tidal and other internal wave motions can be analyzed and described. Events like storm effects and intermittent bursts of internal/inertial wave energy will be of particular interest in relation to the variations in light transmissivity and to the accumulations in the sediment traps.

WORK COMPLETED

Four consecutive deployments of the long-term mooring have been carried out. In addition to the instruments described above, independent temperature sensors procured under this project have been placed on the mooring at depths of 200, 250, 300, 320, 340, 360, 380, 400, 420 and 437 m. The current, temperature, and conductivity sensors from other projects were at 60, 180and 435 m depth. The dates of deployments (d) and recoveries (r), in chronological sequence to date are:

9-27-95 (d), 1-13-95 (r); 1-26-96 (d), 5-22-96 (r); 5-22-96 (d), 6-19-96(r); 7-22-96 (d), 11/15/96 (r); 1/22/97 (d), 7/15/97 (r); 7/21/97 (d).

The extended gap between the recovery and deployment in May-June, 1996, was owing to the inadvertent recovery of the mooring by a fishing trawler. The instruments were retrieved from the fishing vessel, and the data have been successfully recovered.

This project funding has expired (April, 1997), but in order to maintain the long time series, the available sensors were deployed on the most recent mooring. No further deployments are planned.

RESULTS

The major results from the first two deployments of the temperature sensors and data from the other moored instruments were presented at the Fall 1996 AGU Meeting in San Francisco (Cacchione, et al.,1996). Time-series plots and spectra of the temperature data show that tidal motions dominate the records below about 100 m. At depth, the M2 and and K1 tidal constituents are the most prominent constituents, with some indication that the energy in the first harmonic, MS4, increases near the sea bed. Using recent CTD data taken during the mooring deployment, we find that the characteristic ("ray") ofMS4 is closely aligned with the bottom slope in this region. This might explain some of the observed intensification of the energy at this frequency. Continued investigation of this finding is in progress.

There is considerable temporal variation on the strength of the internal temperature oscillations at semi-diurnalfrequency. A statistical description of these variations is in progress, and the causes of the variations are under investigation are under study. The long-term measurements of currents and temperature provided by the bottom tripod located shoreward of the mooring on the continental shelf in about 60 m depth will be examined for correlation with the mooring data.

At the shallower depths (<100 m), considerable warming occurred during and after the passage of the largest storm of the 95-96 winter in this region. Average temperature at about 60 m depth increased nearly 5.0 degrees C. This was likely caused by the offshore transport of warm water in the storm's aftermath when the winds shifted to NW ("upwelling favorable").

The bottom slope near the site is about 2 degrees (slope = 0.035). Based on the latitude, slope and density profiles, the M2 tide is subcritical ("reflective") under these conditions. Accordingly, we do not observe in the temperature data any appreciable increase in the spectral values of the M2 tide toward the sea bed. It is noteworthy, however, that higher on the slope near the shelf break the M2 tide is estimated to be nearly critical. The potential effects of this critical condition will be examined using density information provided by additional CTD profiles which were collected during the last deployment of the mooring.

IMPACT ON SCIENCE AND TECHNOLOGY

This project will enhance our understanding of the nature of internal waves and tides over a sloping bottom. It will also provide insights on theme chanisms and variability of the shoaling/reflection processes over longtime periods (> 1 year). In addition, the effects of shoaling internal waves on the sea bed will be examined, hopefully leading to an assessment of the role that these waves might have in sediment redistribution and transport on the slope.

TRANSITIONS

The results from these data have been discussed with other investigators funded by ONR Physical Oceanography, and with other principal investigators in the STRATAFORM project.

RELATIONSHIP TO OTHER PROJECTS

This project is integrated into the STRATAFORM program sponsored by the Marine Geology and Geophysics Program in ONR (J. Kravitz, Program Manager). Cacchione is one of the principal investigators and organizers of STRATAFORM, and will incorporate this work into his other tasks involving studies of sediment transport by oceanic processes. This project adds a distinctive physical oceanographic component to the sediment dynamics investigations.

REFERENCES

Cacchione, D.A., Wong, F., Sternberg, R., and Ogston, A., 1996, Internal waves on the northern California continental slope - model and measurements. (abs) Trans. Amer. Geophys. Union, EOS, 77 (46), p. F330.